However, ions traveling along the inside of the beam envelope travel some distance from the line 9 before reaching Region III. If an ion experiences a charge exchanging collision between the line 9 and Region III, the neutralized particle is no longer steered by the angle corrector magnet 16 and follows a straight line path toward a portion of the wafer 3 further to the right than the ion would have originally impacted. This tends to cause extra dosing of the right side of the wafer 3, and may nearly counteract charge exchanging collisions that more frequently occur along outer paths of the beam 2. The inventor has found that the effects of vacuum fluctuations on beam uniformity in the arrangement shown in FIG. 3 typically have a relatively small effect on implant uniformity. However, in other configurations, vacuum fluctuations may have a greater effect on implant uniformity. In those cases, the controller 5 may adjust the beam parameters to counteract the effects of vacuum fluctuation.

FIG. 4 shows a flowchart of steps of a method for adjusting ion implantation parameters based on an ion beam current reference value and a measured beam current.

In step S10 an ion beam is generated. The ion beam can be generated in any one of several well-known ways in the art and can include any type of desired ion species at any desired energy. The ion beam typically includes substantially only one ion species, but the beam may include different ion species, if desired.

In step S10, a reference value for the ion beam current is determined. The ion beam current is a measure of an amount of charge carried by particles in the beam per unit area or for a total cross-sectional area of the beam over a period of time. The reference value can be a measured beam current when the vacuum level within an ion implantation system is at a desired level. For example, the ion beam current may be measured before implantation of a wafer has begun, when the vacuum level within the ion implantation system and along an ion beam path is relatively high and stable.

In step S30, a material, such as a semiconductor wafer, is implanted using the ion beam generated in step S10. Implantation of the material can be performed by directing the ion beam at a desired angle toward the semiconductor wafer such that energetic particles in the beam are implanted in the material.

In step S40, the ion beam current is measured during implantation. The beam current can be measured using any desired beam current measuring device, such as a Faraday cup, a detector that uses calorimetry or beam-induced magnetic field measurements, or other detector. The ion beam current can be measured at a position adjacent the material being implanted or along the beam path to the material being implanted.

In step S50, ion implantation parameters are adjusted based on the reference value for the ion beam current and the measured beam current during implantation. For example, the difference between the reference value and the measured current can be determined and ion implantation parameters can be adjusted based on the difference value. Various different ion implantation parameters can be adjusted based on the difference value. For example, the wafer scan rate can be adjusted, e.g., decreased, to accommodate for a decrease in dosing level resulting from vacuum fluctuations along the beam path during implantation. Other ion implantation parameters can be adjusted, such as the beam current, the beam scan rate or frequency, beam uniformity, the evacuation rate of a vacuum system used to control the vacuum level along the beamline, etc. The difference value between the reference value for the beam current and the measured

beam current during implantation can be scaled to account for non-line of sight collisions that contribute to a decrease in detected beam current and a decrease in wafer dosing, and line of sight collisions that contribute to a decrease in detected beam current, but do not affect wafer dosing. Thus, the difference value can be scaled and implant parameters can be adjusted so that a desired dose is delivered to the semiconductor material.

While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, preferred embodiments of the invention as set forth herein are intended to be illustrative, not limiting. Various changes may be made without departing from the invention.

What is claimed is:

1. An ion implantation system comprising:

means for generating an ion beam;

means for determining an ion beam current reference level;

means for measuring an ion beam current during implantation; and

means for adjusting an ion implantation parameter to compensate for vacuum fluctuations during implantation based on the reference level and the measured ion beam current, and not based on a detected pressure.

2. An ion implantation system comprising:

a beam generator that generates an energetic ion beam and directs the beam toward a semiconductor wafer;

a detector that detects an ion beam current;

a wafer drive that moves the semiconductor wafer in a direction transverse to the ion beam path; and

a controller that receives signals from the detector representative of a detected ion beam current, detects a vacuum fluctuation based on the detected ion beam current, and controls the wafer drive to adjust a wafer scan rate to compensate for the vacuum fluctuation during implantation.

3. The apparatus of claim 2, wherein the controller scales the difference value to account for non-line of sight and line of sight charge exchanging collisions experienced by ions in the beam along the ion beam path.

4. The apparatus of claim 3, wherein the difference value is scaled based on a ratio of line of sight collisions to non-line of sight collisions.

5. The apparatus of claim 2, further comprising a vacuum system, and wherein the controller controls the vacuum system to begin evacuation based on the determined difference value.

6. The apparatus of claim 2, wherein the detector is a Faraday cup positioned adjacent a semiconductor wafer.

7. The apparatus of claim 2, wherein the beam generator includes an angle corrector magnet.

8. The apparatus of claim 2, wherein the ion beam current reference value is determined based on an ion beam current measured while a vacuum level along the ion beam path is stable.

9. The apparatus of claim 2, wherein the ion beam current reference value is retrieved by the controller from a memory.

10. The apparatus of claim 2, wherein the controller detects a vacuum fluctuation based on a difference value between an ion beam current reference value, which corresponds to an ion beam current in the absence of vacuum fluctuations along an ion beam path, and an ion beam current measured in the presence of vacuum fluctuations along the ion beam path.

11. The apparatus of claim **2**, wherein the controller adjusts an ion implantation parameter in addition to the wafer scan rate to adjust for wafer dosing non-uniformity in two dimensions.

12. The apparatus of claim **2**, wherein the controller adjusts a wafer scan rate and a beam scan rate.

13. The apparatus of claim **12**, wherein the controller adjusts the wafer scan rate and beam scan rate based on two scale factors.

14. The apparatus of claim **2**, wherein the controller adjusts the wafer scan rate using a scale factor that is mathematically derived by modeling the implantation system.

15. The apparatus of claim **14**, wherein the controller uses a scale factor that has been determined based on calculated beam path length neutral particle density products that are obtained, at least in part, from a model of an ion beam path and a vacuum system in the implantation system.

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